Techniques for Producing Coastal Land Water Masks from Landsat and Other Multispectral Satellite Data

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Coastal erosion and land loss continue to threaten many areas in the United States. Landsat data has been used to monitor regional coastal change since the 1970s. Many techniques can be used to produce coastal land water masks, including image classification and density slicing of individual bands or of band ratios. Band ratios used in land water detection include several variations of the Normalized Difference Water Index (NDWI). This poster discusses a study that compares land water masks computed from unsupervised Landsat image classification with masks from density-sliced band ratios and from the Landsat ETM band 5. The greater New Orleans area is employed in this study because of its abundance of coastal habitats and its vulnerability to coastal land loss. Image classification produced the best results based on visual comparison to satellite color composite image displays. Density-sliced Landsat ETM band 5, Normalized Difference Vegetation Index (NDVI), and three versions of NDWI imagery also enabled useful land water masks. Producing land water masks from NDVI or NDWI based on NIR and green bands is noteworthy because these techniques allow land water masks to be generated from multispectral satellite sensors without a blue band (e.g., ASTER, AWIFS, and Landsat MSS). NDWI techniques also have potential for producing land water masks from coarser scaled satellite data, such as MODIS.

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Figure 1 – Landsat ETM+ true color composite view of study area with focus area delineated in yellow (Landsat ETM+ data collection occurred 9/17/2000).

Methods

The image maps shown here were produced primarily with ERDAS IMAGINE® software, using ESRI ArcGIS® and RSI ENVI® in a lesser capacity. Figure 1 shows the main study area, which includes New Orleans, Louisiana. Landsat data were mainly used in this study with NDVI and NDWI imagery produced in accordance with published algorithms (Table 1) implemented with IMAGINE Spatial Modeler software. Landsat ETM+ data collected September 17, 2005 was the primary data set employed in this study (Figures 2 and 3). Landsat ETM+ data was processed into an ISODATA unsupervised classification containing 25 cluster classes. Cluster classes pertaining to water surfaces were identified interactively using screen displays and assigned a blue color (Figure 3). Each individual band ratio output (e.g., NDWI) as well as Landsat ETM+ band 5 imagery was density sliced to produce land water masks. In doing so, a color lookup table was applied so that water areas were indicated in blue tones (Figures 4-9). A Landsat change detection image was computed to assess coastal erosion trends from 1974 to 2000 (Figures 10-13). Land water masks were also computed using MODIS, AWIFS, and ASTER imagery (Figures 14-19).

Water Detection Method	Figure(s)	Formula	Reference
Unsupervised Classification	Figures 2 and 3	Isodata Clustering of VNIR-SWIR bands	Erdas Field Guide 2003
Thresholding Single Band	Figure 4	Single SWIR Band	Barras et al. 2003
Thresholding NDVI	Figure 5	NDVI = (NIR-Red)/ (NIR+Red)	Tucker 1979; Chrysoulakis and Cartalis 2003
Thresholding NDWI - Version 1	Figure 6	NDWI = (NIR-SWIR)/(NIR+SWIR)	Gao 1996
Thresholding NDWI - Version 2	Figure 7	NDWI = (Red-SWIR)/(Red+SWIR)	Kearney et al. 2002
Thresholding NDWI - Version 3	Figure 8	NDWI = (NIR-Blue)/(NIR+Blue)	Huggel 2002
Thresholding NDWI - Version 4	Figure 9	NDWI = (Green-NIR)/(Green+NIR)	McFeeters 1996

Table 1 – Techniques considered in coastal land water detection study.

Figure 2 – Landsat ETM+ color composite with bands 5, 2, 1 loaded into the RGB color guns.

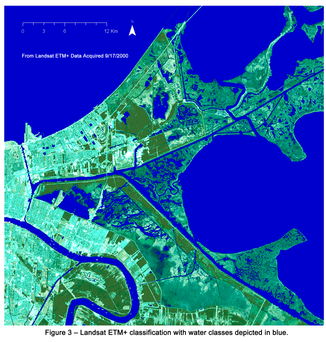

Figure 3 – Landsat ETM+ classification with water classes depicted in blue.

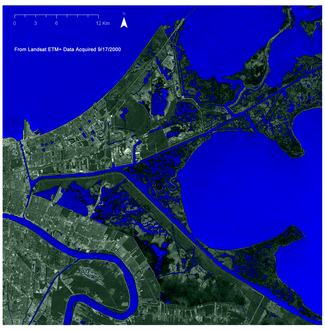

Figure 4 – Land water mask from density sliced Landsat ETM+ band 5 (water digital numbers are depicted in blue tones).

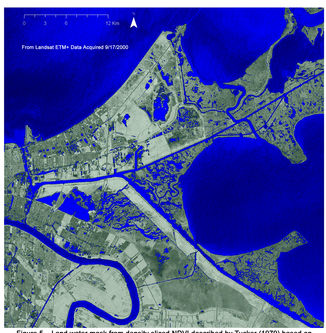

Figure 5 – Land water mask from density sliced NDVI described by Tucker (1979) based on Landsat ETM+ data (water digital numbers are depicted in blue tones).

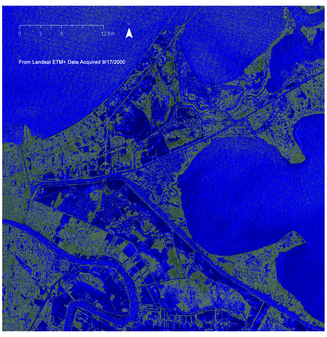

Figure 6 – Land water mask from density sliced NDWI using Gao (1996) algorithm and Landsat ETM+ data (water digital numbers are depicted in blue tones).

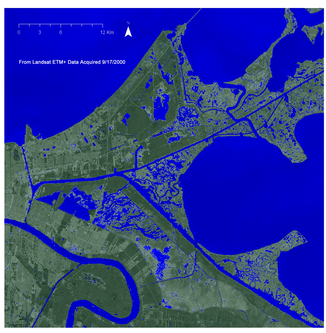

Figure 7 – Land water mask from density sliced NDWI using Kearney et al. (2002) algorithm and Landsat ETM+ data (water digital numbers are depicted in blue tones).

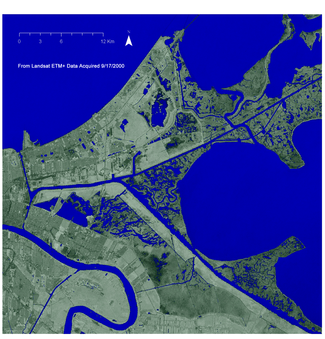

Figure 8 - Land water mask from density sliced NDWI using Huggel et al. (2003) algorithm and Landsat ETM+ data (water digital numbers are depicted in blue tones).

Figure 9 - Land water mask from density sliced NDWI using McFeeters (1996) algorithm and Landsat ETM+ data (water digital numbers are depicted in blue tones).

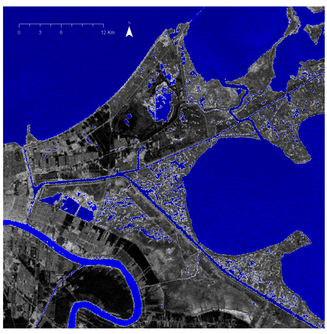

Figure 10 - Land water mask from density sliced NDWI using McFeeters (1996) algorithm and Landsat MSS data from 4/9/1976 (water digital numbers are depicted in blue tones).

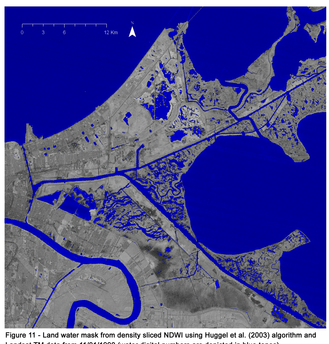

Figure 11 - Land water mask from density sliced NDWI using Huggel et al. (2003) algorithm and Landsat TM data from 11/01/1990 (water digital numbers are depicted in blue tones).

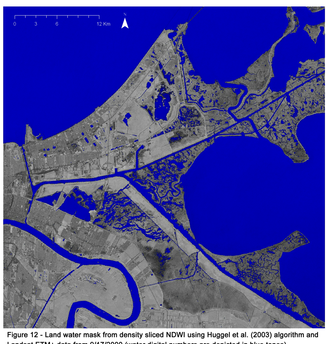

Figure 12 - Land water mask from density sliced NDWI using Huggel et al. (2003) algorithm and Landsat ETM+ data from 9/17/2000 (water digital numbers are depicted in blue tones).

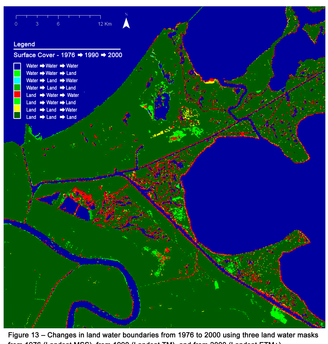

Figure 13 – Changes in land water boundaries from 1976 to 2000 using three land water masks from 1976 (Landsat MSS), from 1990 (Landsat TM), and from 2000 (Landsat ETM+).

Results

The techniques tried in this study enabled effective coastal land water masks overall except for the one produced from the NDWI algorithm of Gao (1996). The land water mask from unsupervised Landsat image classification appears to be slightly more effective compared to satellite color composite imagery. The unsupervised classification enabled highly turbid river and bayou channels to be more readily identified compared to other techniques tried. However, the results from classification is similar to what can be obtained from density slicing Landsat ETM+ (or TM) band 5, NDVI, or three of the NDWI versions tried (excluding the Gao (1996) version). Density slicing Landsat ETM+ band 5 imagery was easiest and quickest to perform. The NDVI and one NDWI version (McFeeters, 1996) are noteworthy techniques because they do not require either a blue band or a SWIR band. This is useful for coastal change surveys that involve satellite imagery without blue and/or SWIR bands (e.g., multi-temporal surveys with Landsat MSS in conjunction with TM and ETM+ shown in Figures 10-13). Land water masking techniques for Landsat data may also aid comparable applications with other satellite data (e.g., MODIS, AWIFS, and ASTER). These findings are preliminary; additional quantitative accuracy assessment is needed to complete this study using high resolution satellite and aerial imagery as reference data.

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Acknowledgements

Participation in this work by Science Systems and Applications, Inc., was supported by the NASA Applied Sciences Directorate under Task Order NNS04AB54T at the John C. Stennis Space Center, Mississippi.

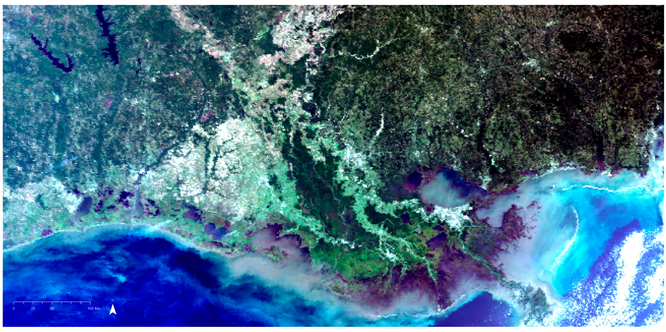

Figure 14 – MODIS Terra true color composite image of Texas, Louisiana, Mississippi, and Alabama coastal areas (this 1-kilometer data was acquired 9/17/2000, the same date as the Landsat ETM+ scene).

Figure 15 – Land water mask from density sliced NDWI using Huggel et al. (2003) algorithm and MODIS Terra data (water digital numbers are depicted in blue tones overlain onto MODIS imagery shown in Figure 14).

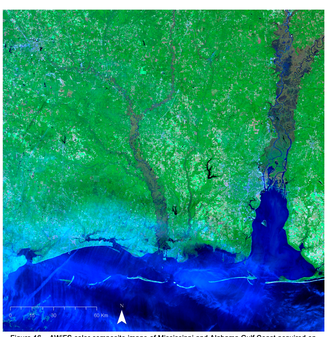

Figure 16 – AWIFS color composite image of Mississippi and Alabama Gulf Coast acquired on 01/17/2005 (this RGB is composed of SWIR, NIR, and green bands and is courtesy of Space Imaging).

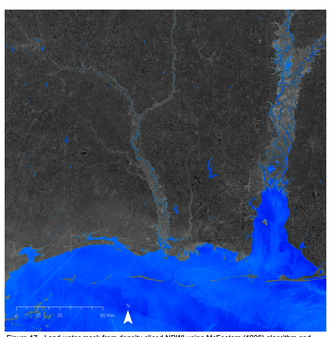

Figure 17 - Land water mask from density sliced NDWI using McFeeters (1996) algorithm and aforementioned AWIFS data (water digital numbers are in blue tones).

Figure 18 – ASTER color composite image of Bay Saint Louis, Mississippi, Gulf Coast acquired on 08/16/2000 (this RGB is composed of NIR, SWIR, and green bands).

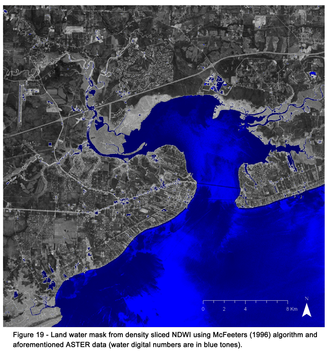

Figure 19 - Land water mask from density sliced NDWI using McFeeters (1996) algorithm and aforementioned ASTER data (water digital numbers are in blue tones).

REPORT DOCUMENTATION PAGE

Form Approved
OMB No. 0704-0188

1. REPORT DATE *(DD-MM-YYYY)*	2. REPORT TYPE	3. DATES COVERED *(From - To)*
25-07-2005	Conference Poster	Oct 2003 - Oct 2005

4. TITLE AND SUBTITLE
Techniques for Producing Coastal Land Water Masks from Landsat and Other Multispectral Satellite Data

5a. CONTRACT NUMBER
NASA Task Order NNS04AB54T

5b. GRANT NUMBER

5c. PROGRAM ELEMENT NUMBER

6. AUTHOR(S)
Spruce, Joseph P. (1)
Hall, Callie (2)

5d. PROJECT NUMBER
SWR N24A-05CM-00

5e. TASK NUMBER

5f. WORK UNIT NUMBER

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
(1) Applied Sciences Directorate, Science Systems and Applications, Inc., Bldg. 1105, John C. Stennis Space Center, MS 39529
(2) Applied Sciences Directorate, National Aeronautics and Space Administration, Code MA00, Bldg. 1100, John C. Stennis Space Center, MS 39529

8. PERFORMING ORGANIZATION REPORT NUMBER

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Applied Sciences Directorate, National Aeronautics and Space Administration, Code MA00, Bldg. 1100, John C. Stennis Space Center, MS 39529

10. SPONSORING/MONITOR'S ACRONYM(S)
NASA ASD

11. SPONSORING/MONITORING REPORT NUMBER
SSTI-2220-0048 (Modified)

12. DISTRIBUTION/AVAILABILITY STATEMENT
Publicly available STI per NASA Form 1676

13. SUPPLEMENTARY NOTES
Twenty-Fifth Annual ESRI International User Conference, July 25-29, 2005, San Diego Convention Center, San Diego, California

14. ABSTRACT

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15. SUBJECT TERMS
satellite remote sensing, coastal, land water masks, erosion, land loss

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19b. NAME OF RESPONSIBLE PERSON
a. REPORT	b. ABSTRACT	c. THIS PAGE			Callie Hall
					19b. TELEPHONE NUMBER *(Include area code)*
U	U	U	UU	2	(228) 688-2360